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ADVANCE SUMMARY
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19 June 46

Title: Note on the Design of a Pilotless Target Aircraft

File No: RAE Tech Note No. Aero 1716, November 1945

Author: F. Smith, M.A.

1. Report covers preliminary performance calculations for the design of a high-speed pilotless target airplane. Variation of wing loading and endurance are considered. The gas turbine is favored rather than the impulse-duct jet-propulsion unit. Author concludes that it is possible to disign a target airplane to meet service requirements and that the chief need would be for the development of a suitable remote control, particularily if it were to land after flight. Production of airplane and jet unit considered not a major problem.

2. A typical design would employ a gas turbine and have a top speed of 550 mph with wing are of 50 sq ft.

Collation: Total pages 8, Text 4 pp. Charts 4 pages.

J. W. McCamley
Analyst

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R.A.E. Tech. Note No. Aero.1716

November, 1945.

ROYAL AIRCRAFT ESTABLISHMENT, FARNBOROUGH

Note on the Design of a Pilotless Target Aircraft

by

F. Smith, M.A.

R.A.E. Ref: Aero.1447R/159

SUMMARY

Simplified calculations for a high speed pilotless target aircraft using either a gas turbine or impulse duct jet propulsion unit are given. Variation of wing loading and endurance are considered. The gas turbine is shown to be a better all-round engine than the impulse duct, which is a relatively inefficient engine.

A typical design of aircraft using a gas turbine engine and having a top speed of 550 m.p.h., take-off wing loading of 60 lb./sq.ft. and wing area of 50 ft^2 has the following characteristics:-

Take-off speed	140 m.p.h.
Ground level endurance (full throttle)	1.05 hrs.
20,000 ft. endurance (full throttle)	1.85 hrs.
20,000 ft. maximum endurance (at 210 m.p.h.)	3.5 hrs.
Wing loading, fuel gone	23 lb./sq.ft.
Absolute ceiling	45,000 ft.
Rate of climb	5900 ft./min.
Thrust, ground level at 300 m.p.h.	990 lb.

Weight analysis	
Structure	750 lb.
Controls	100 lb.
Engine	600 lb.
Fuel	1550 lb.
All-up weight	3000 lb.

The aircraft can be scaled up or down in size, the thrust and weight being proportional to wing area.

1 Introduction

There is always a demand from all the Fighting Services for a pilotless target aircraft to be used during gun firing exercises, and it has been suggested that a small expendable target remotely controlled by radio would be more suitable than fighter aircraft specially converted for this work. High speeds are demanded, although the target should represent the present day fighter in manoeuvrability.

To satisfy these demands for a special target simplified calculations have been made using either a gas turbine engine or an impulse duct engine (similar to the engine used on the German pilotless flying bomb, V.1). Wing loading and endurance have been taken as the main variables and the performance of the target aircraft calculated for a range of values of these variables.

2 Method of Calculation

The structure weight has been taken throughout as 25% of the all up weight corresponding to fighter design. Flaps and undercarriage have not been included, since a catapult take-off is recommended and recovery of the target is not a definite requirement. If the target is to be landed a metal skid could be fitted or a parachute used to bring it back to earth. These additions would require small alterations to the general design but the present calculations are not intended to represent a comprehensive design but only to indicate the general design and performance.

The aircraft, apart from structure, consists of engine, fuel and controls (including the radio control). The engine data have been based on W.1.A. gas turbine and German V.1 impulse duct data; the ground level thrust refers to that at 300 m.p.h. - a mean between climbing speed and top level speed. For the W.1.A. the ground level thrust was taken as 900 lb. (modification of the engine to work nearer the surge limit at ground level was envisaged), specific weight (lb.per lb. thrust) 0.60, specific fuel consumption 1.5 (lb./hr. per ~~lb. thrust~~). For the impulse duct the ground level thrust was 700 lb. specific weight 0.50, and specific fuel consumption 4.0 (lb./hr. per lb. thrust). The non-dimensional data have been used assuming that larger or smaller engines could be designed to the same efficiencies as the W.1.A. and V.1 engines. The thrust was assumed to vary with height in proportion to the air density, which is unfavourable to the gas turbine, although this simplification is covered somewhat by re-design nearer to the surge limit, and favourable to the impulse duct.

The controls, including radio, have been assumed to weigh 200 lb. for an aircraft of 100 sq.ft. wing area - based on a Spitfire installation. The control weight should vary roughly as (wing area)$^{3/2}$, whilst the radio weight is roughly constant. As a compromise the total weight of the controls and radio have been taken to be proportional to wing area.

For purposes of estimating the aircraft profile drag it has been assumed that the engine is mounted above the fuselage (for ease of servicing) after the manner of the Heinkel 162 (Volksjäger) design. This suggested design does not represent a large increase in drag over the design with the engine enclosed in the fuselage because of the need to reserve a large space in the fuselage for fuel. The following drag analysis has been used:-

	Drag in lb. at 100 ft./sec. for 100 sq.ft. wing area		
	Wing loading 20 lb./ft.^{2}	Wing loading 40 lb./ft.^{2}	Wing loading 60 lb./ft.^{2}
Wing, 10% chord thickness	9	9	9
Fin and Tail plane, 8% chord thickness	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$
Engine	$4\frac{1}{2}$	5	6
Fuselage	$3\frac{1}{2}$	7	$10\frac{1}{2}$
Miscellaneous, Aerials, etc.	2	$2\frac{1}{2}$	3
Total drag	$20\frac{1}{2}$	25	30
Drag coefficient	0.0172	0.0210	0.0252

It has been assumed that the design of the W.1.A. engine would result in a reduction in overall diameter. The smaller diameter of the impulse duct is offset by the larger external drag caused by the intermittent flow to the engine.

The induced drag has been taken to be 10% greater than theoretical, in accordance with the results of flight tests on jet propelled aircraft.

3 Results

The results of the calculations are shown in fig. 1-8. Time of flight at full throttle, ground level, and wing loading have been taken as the variables and the values of fuel, thrust ÷ wing area, top speed, ceiling, rate of climb, and endurance at 20,000 ft. have been expressed as functions of these two variables. The top speed is roughly constant with height, except near the ceiling, due to the assumption of thrust variation with air density.

It will be seen that the use of the impulse duct engine results in a much poorer all round performance than that obtained with the gas turbine engine*. For instance with a top speed of 500 m.p.h. and take-off wing loading of 40 lb./sq.ft. the endurance full throttle, ground level, of the gas turbine design is 0.98 hours compared with that of 0.39 hours for the impulse duct design.

The services have recently expressed the desire for a 550 m.p.h. target having a maximum endurance of $3\frac{1}{2}$ hours. Using the curves of figs. 1-8 for the gas turbine design and taking a take-off wing loading of 60 lb./sq.ft., top speed 550 m.p.h. and wing area of 50 sq.ft. we have the following design data:-

* There is probably no large difference in the overall cost of targets with the alternative power units as the greater cost of the turbine would be offset against the larger fuselage required to contain the fuel for the impulse engine.

Take-off speed	140 m.p.h.
Ground level endurance (full throttle)	1.05 hrs.
20,000 ft. endurance (full throttle)	1.85 hrs.
20,000 ft. maximum endurance (at 210 m.p.h.)	3.5 hrs.
Wing loading, fuel gone	29 lb./sq.ft.
Ceiling, absolute	45,000 ft.
Rate of climb	5900 ft./min.
Thrust, ground level at 300 m.p.h.	990 lb.

Weight analysis	
Structure	750 lb.
Controls	100 lb.
Engine	600 lb.
Fuel	1550 lb.
All-up weight	3000 lb.

If this aircraft is thought to be too small for its target duties the figures quoted can be scaled up to any desired size of aircraft. The cost will, of course, rise in proportion to the size.

4 Conclusion

It has been shown that it is possible to design a target aircraft to fulfil the Services requirements. The production of the aircraft and a suitable gas turbine engine presents no major problems. The chief need would be for the development of a suitable remote control, particularly if it were required to land the aircraft after flight.

Attached:

Figs. 1-8 - Drg. Nos. 17936.S - 17939.S

Circulation:

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A.D./R.D.T.1.
S.R.1.
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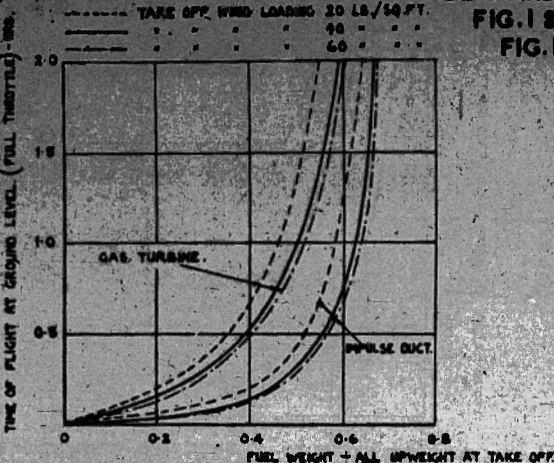
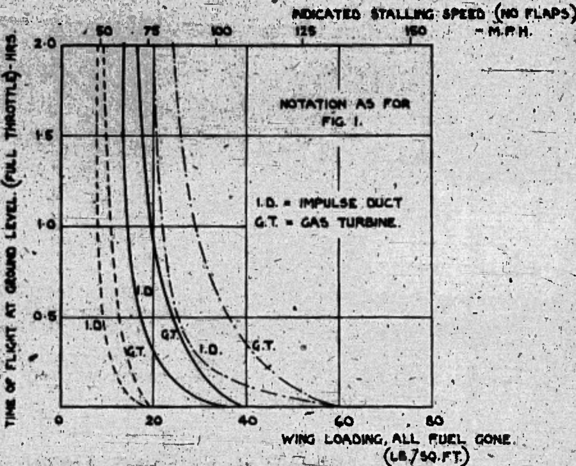
FIG. 1 & 2

FIG. 1



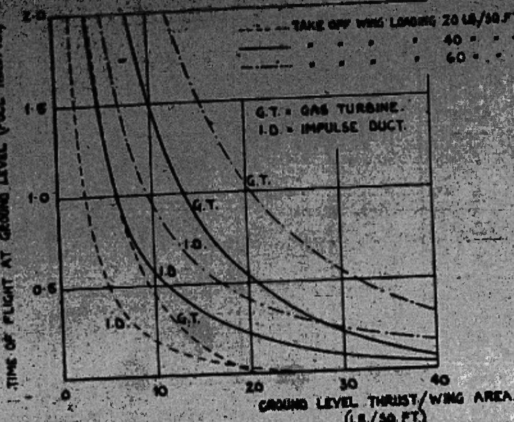
QUANTITY OF FUEL - TIME OF FLIGHT.

FIG. 2



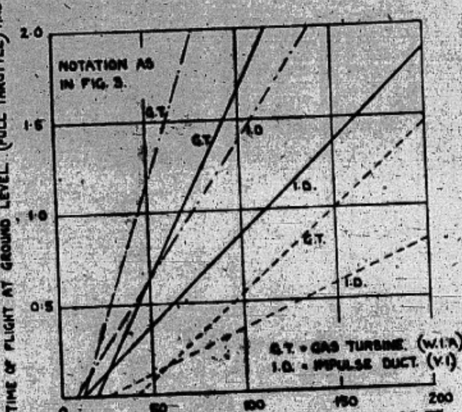
WING LOADING - (FUEL GONE)
TIME OF FLIGHT.

FIG. 3



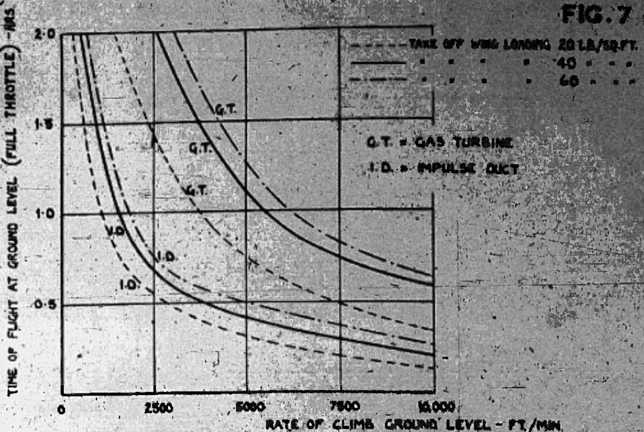
THRUST LOADING - TIME OF FLIGHT.

FIG. 4



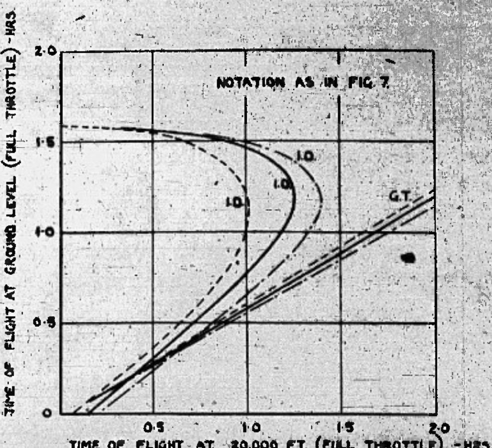
WING AREA FOR EXISTING ENGINES - TIME OF FLIGHT.

FIG. 7



RATE OF CLIMB - TIME OF FLIGHT.

FIG. 8



TIME OF FLIGHT (20000 FT.)-
TIME OF FLIGHT (GROUND LEVEL.)

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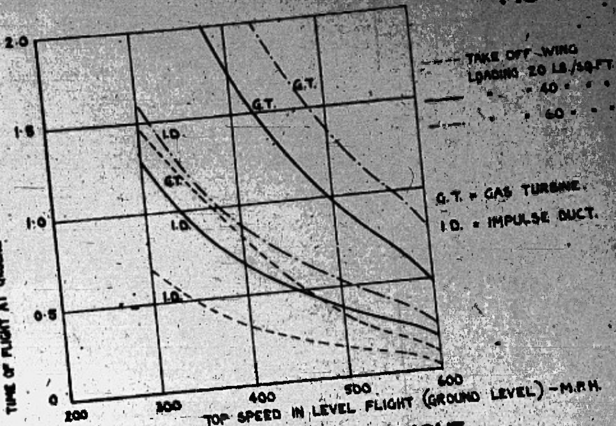
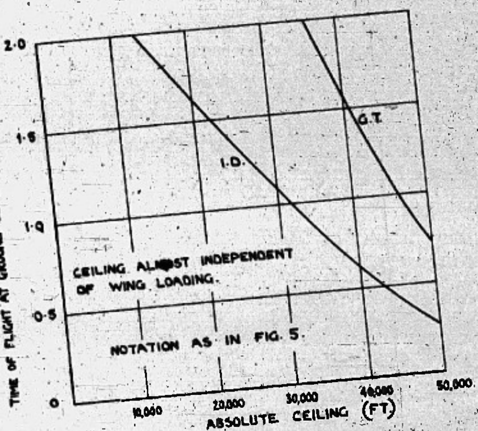
FIG. 5 & 6

FIG. 5



TOP SPEED – TIME OF FLIGHT.

FIG. 6



ABSOLUTE CEILING – TIME OF FLIGHT.

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